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CONDITIONS OF INFLAMMABILITY.

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It is an old saying that "fire is a good servant but a hard master." While we accept this proverb as the embodiment of the general experience of men on this subject, yet we may not comprehend the full extent of the truth embodied in this familiar saying. There are many things essential to our comfort and well-being to which we have become so accustomed that we hardly think of them, till by some chance we are in danger of losing them when we realize

How blessings brighten as they take their flight!

What would become of health, comfort, or even of civilization if we were deprived of the help of this hot-headed and quick-tempered servant, fire? The extraction of metals from their ores, and even the use of the metals we now have, would soon cease if we were deprived of the use of fire; food must be eaten raw, and a thousand evils would crowd into the place of blessings we now enjoy, and we should find changes taking place in most unexpected quarters. We can scarcely conceive of the degradation and savagery of a race who did not know the use of fire.

Two years ago the industry of this nation received a rude shock in the railroad strikes that swept like a wave of madness over our country, and we held our breath in dread and asked, What shall the end be? But, instead of railroad employés, suppose the chemical forces should strike for better positions, higher wages, or even for back pay! Suppose that Oxygen should complain that he is always set to do the dirtiest and most repulsive work, compelled to be the scavenger of all forms of life—with never a holiday—a penny of pay—not even a cheap vote of thanks—and should refuse to work any longer on such hard terms. Suppose that Carbon should say that he had been twitted too often of his black face; that we had despised him and turned up our aristocratic noses at his menial, but useful ways; that capitalists had combined to compel him to grind in the prison-house of toil, without reward, thanks, or even recognition—and he will strike for something better! How would we fare in the face of such a strike? Not alone would railroads and steamboats stop, but every arm of industry would wither in an hour, and all life would cease in the twinkling of an eye.

Sancho Panza, in a burst of gratitude, exclaimed, "Blessed be the man who invented sleep!" We make no inquiry for the man who "invented" fire; his name is lost in the darkness that antedates antiquity itself. History will never reveal his name, for the use of fire must have long preceded that degree of civilization which renders authentic history or even tradition possible. Mythology relates that Prometheus, out of pity for the wretched condition of mortals, stole this choicest possession of the immortals, and thus braved the fury of omnipotent Jove. The "stealing fire from heaven" may be a poetic form of stating the prosaic fact that he obtained fire from some tree struck by lightning, because the lightning darts from the region of the clouds, which was the heaven of mythology, and Jupiter himself is represented with his right hand grasping the thunderbolts.

In most processes of human industry it is the direct and immediate product which is valuable: thus, we melt together sand and alkaline substances to make glass; we boil together grease and alkalies to make soap. But in the use of fire the direct products are of almost no value; these are water, carbonic acid, and ashes. It is only the indirect products of combustion which we value, namely, *light and heat*. We thus transport sunlight into the darkness of night, the warmth of Summer into the frozen realm of Winter. Without this power the refinements of social pleasure which cluster around the domestic hearth and evening lamp would disappear.

Charles Lamb says, "Hail candlelight! Without disparagement to sun or moon, the kindliest luminary of the three. We love to read, talk, sit silent, eat, drink, sleep, by candlelight. They are everybody's sun and moon. This is our peculiar and household planet. Wanting it, what savage, unsocial nights must our ancestors have spent, wintering in caves and unillumined fastnesses! They must have lain about and grumbled at one another in the dark. What repartees could have passed, when you must have felt about for a smile, and handled a neighbor's cheek to be sure that he understood it? This accounts for the seriousness of the elder poetry. Jokes came in with candles."

I have said enough to show the value of fire as a servant: I now call your attention to the fact that he is "a hard master." When I speak of his tyranous behavior when once he gets the upper hand, you at once recall the cities of Portland, Chicago, Boston, and St. Johns, which were almost wiped out by the devouring flames. How many families have rushed forth from stately homes and looked back only to see their doorways filled with belching flames, just as our first parents beheld for the last time the gates of their paradise,

> With dreadful faces thronged, and *fiery* arms.

FIRE-PROOF BUILDINGS.

The waste of property and the danger to life caused by fire have led men to seek means by which they may control this insatiable destroyer. The timid and the prudent alike demand protection from so cruel a master.

Disastrous fires have led prudent men to demand a change in the style of our architecture which shall limit instead of directly feeding these wide-spread conflagrations. It has been the prevailing custom in this country to run up cheap, flimsy but showy buildings which are as inflammable as a tinder-box. The erection in crowded cities of mansard roofs by which the building is surmounted by a large mass of the most combustible material, has been sharply and justly criticised. They are altars of vanity to that cruel divinity Fashion,

and in the hour of peril they are clothed with sacrificial flame where priest and suppliant alike must "pass through the fire" to this modern Moloch.

Men have sought and sought in vain, for buildings which shall be indestructible by fire. The troglodytes, or cave-dwellers, are the only people who have successfully solved this problem. "Fire-proof buildings" have been erected only to go down in wild ruin in some great conflagration. In the great fire of Chicago these "fire-proof" buildings were destroyed as certainly as the flimsiest structures of wood. In the intense heat of that fire, marble, stone, and brick crumbled before the flame, and iron melted like lead. Architects have abandoned all hope of erecting buildings which will withstand any great conflagration. But all great fires are small in their beginning. "Behold how great a matter a little fire kindleth" is the brief history of all our great conflagrations. If we can prevent the small fires we shall escape the big fires.

NATURE OF COMBUSTION.

Before proceeding further in this discussion, let us consider some of the fundamental facts in combustion. Ordinary combustion is the chemical combination of atmospheric oxygen with a combustible body, the attendant light and heat being the result of the transformation of the chemical force into other forms of energy. A combustible body is any substance which can enter into chemical combination with oxygen under the influence of heat. In order that chemical combination may take place between the combustible body and the supporter of combustion, the two must be in contact, and the more perfect the contact the more rapid the combustion, because the greater the number of points at which combination may take place at the same instant. If the contact is perfect throughout the whole mass, as when a combustible gas mixes with oxygen or air, the combustion is instantaneous through the whole mass, and we have an explosion; if the gases only mingle along a plane, we have a flame as in the gas-jet; if the combustible is a solid and not vaporizable by the heat of combustion, there is no flame, and the substance burns with a glow, as seen in burning charcoal and anthracite. But if a combustible solid is finely pulverized and suspended in the air in form of dust, it may burn with an explosion, as may be seen when lycopodium is blown over a flame. Thus by blowing some lycopodium over the lamp-flame you see a flash leap through the air wherever the lycopodium dust is suspended in the air. In this way the flour-mills of Minneapolis were exploded a few years ago; and we have frequent accounts of candy-factories and other places where combustible dust fills the air, being blown up with a veritable explosion. If we greatly increase the extent of surface of some combustible material we may have combustion taking place at ordinary temperatures, as is seen when a solution of phosphorus in bisulphide of carbon is evaporated on paper, the large surface of phosphorus producing sufficient contact with air to cause combustion. I pour this solution of phosphorus over the paper holding some chlorate of potash on its surface, and the paper bursts into flame when the solution has evaporated.

When we compact these combustible materials into a solid mass, we find them less combustible: lycopodium pressed into a solid cake has but moderate combustibility. The lycopodium or fine shavings when pressed into a compact cake burns only slowly. Shavings burn readily, but when compressed into a solid mass, they will not burn better than solid wood. Light and gauzy articles of clothing made of cotton or linen, on account of their combustible

material and large surface contact with air, are very inflammable. You observe how these pieces of muslin and tarlatan burst into flame and consume rapidly when once they touch a flame. Fabrics of wool and silk may expose an equal amount of surface, but they contain so much nitrogen, an incombustible material, that they are less apt to burn.

Combustion is arrested in two ways:

1. *By reducing the temperature of the combustible body below the burning-point.* The most familiar illustration is the use of water in putting out fire. We cannot heat water above 212° F. in the open air—a temperature far below the burning-point of all ordinary combustibles. By pouring water upon a burning body its temperature is rapidly reduced below its burning-point, and the fire is thus extinguished. Substances lighter than water and whose boiling-point is below 212° F., may float, vaporize, and burn upon the surface of water, without being quenched or checked by it. We have a good example of this in the lighter products of petroleum. Where considerable quantities of such materials are burning, water may serve to spread the fire instead of putting it out.

Another example of extinguishing a flame by reducing its temperature is seen in blowing out a candle. If we blow a live coal we increase the energy of combustion by supplying more rapidly the requisite amount of oxygen to support its combustion; but if we blow a candle-flame in the same way, we put out the flame. Since the flame is seen to move with the blast, many persons suppose that the flame is extinguished because it is moved away from its point of support (the wick), just as a feather is blown away by a blast of air. But the real cause is the cooling influence of the blast of air on the flame, for I can blow a much stronger blast of hot air without extinguishing the flame. I blow a jet of cold air upon this candle-flame and readily extinguish the flame; I blow a jet of hot air upon the candle-wick and readily relight it. But I may bring the intensely hot blowpipe flame to bear upon a very combustible body without burning it provided it does not become heated. I blow the jet of hot air, which readily lighted the candle, upon a piece of paper pasted on the smooth face of this hammer, but the paper does not burn or even scorch. No substance need take fire if it will "keep cool."

2. *We may extinguish flame by preventing the access of free oxygen to the combustible body.* Organic bodies will char when strongly heated, but will not inflame when free oxygen is excluded. I wish to call your attention to this means of preventing or arresting flame. Water may serve this purpose where it floods the burning body and thus shuts off the air; but if the body floats on the water the air will not be excluded, and in such case we may use ammonia-water, which forms an atmosphere deficient in oxygen by evaporation of ammonia; or we may set free an atmosphere of carbonic acid (as by Babcock's fire-extinguisher), or we may exclude the air by sand, and earth of any kind, or even smother the flame by a blanket. A handful of sulphur thrown into the fire will check or even extinguish the burning of a chimney by using up all the oxygen of the air in the chimney; a handful of salt checks the combustion, because the volatilized salt coats over the soot and prevents access of air.

One very important application of the principle of preventing combustion by excluding air is to coat the inflammable material with some substance which will exclude free oxygen. To apply and enforce this principle is the object of this paper.

Where very inflammable materials are in use whose burning would not only

destroy property but imperil life, it becomes a matter of great importance to use such preventives, especially when they are inexpensive and do not injure in any way the materials to which they are applied. This is in a marked degree true of the very inflammable materials which form the apparel of women and children. Accidents from this cause are frequent and the results most shocking. A few years ago the Archduchess Sophia of Austria stepped on a match which ignited, setting fire to her clothes, and she burned to death in the midst of her terrified maids. But we need not cross the sea for examples of this kind; almost every week the newspapers give us the agonizing details of some deplorable accident of this kind, and women and children are the victims in nearly every instance.

Such accidents may be repeated any day in any home in this State. Yet we speak of them as accidents against which we are helpless and which should move our pity, rather than wrongs which we should prevent. As a contribution to this end I place before you the results of some investigations made by others, and some of my own.

APHLOGISTICS.

Gay-Lussac many years ago recommended the phosphate of ammonia as a substance which would render the most combustible fabrics practically uninflammable. Here is some gauze which has been steeped in a solution of this salt, and although it will char in the gas-flame it will not burn with flame, and a dress thus protected could not catch fire and roast its wearer; you cannot make it blaze, though held in the flame. But when this salt was dissolved in the gelatinized starch in stiffening clothes, it was found that the clothes would not iron smooth, and it was rejected accordingly. Woman will go to the stake with the cheerful zeal of a martyr, but no one need ask her to wear fabrics that will not iron smooth.

The tungstate of soda was recommended in 1860 by Versman and Oppenheim as a means of rendering cotton and linen goods uninflammable. Here is a piece of tarlatan which has been steeped in solution of tungstate of soda, and though completely dry you see it does not blaze when held in the flame. In In the laundry of Queen Victoria the starch sizing contains 20 per cent of tungstate of soda, and 3 per cent of phosphate of soda. The starched clothes iron smooth, and the salts do not injure the goods or harm the wearer in any way. Here is tarlatan treated in this way, which you see is not readily combustible. Yet the tungstate of soda has not come into general use, possibly because it is so seldom found in the shops.

The hyposulphite of soda I find to have marked power of preventing flame, but I do not think it will come into general use because acid perspiration would evolve sulphurretted hydrogen from this salt.

I also find that common borax has a singular power of preventing flame. Here are specimens of paper muslin and tarlatan which have been dipped in solution of borax and dried, and you see they will not inflame even when held directly in the gas-flame. The reason why borax prevents flame is that it melts and forms a glassy coating over the surface of the paper, muslin, etc., thus preventing that free access of air which is essential to flame. To show how complete is this shielding influence of borax, I saturate a paper treated with borax with benzine and set it on fire; the benzine burns fiercely, but the paper, though wrapped in flames, does not itself inflame.

This protective influence of borax may be increased by adding to the borax a little more than its own weight of boracic acid. If you will dissolve 3 ounces

of borax and 4 ounces of boracic acid in a pint of boiling water, and wet any kind of cloth in this solution, you will find it incapable of burning with flame. If one part of this solution is added to 3 parts of water and this used to make the gelatinized starch for laundry purposes, the dress-materials treated with it will not be dangerously inflammable.

But the simplest and easiest way to make your cotton and linen clothes safe from taking fire is to dissolve a heaped teaspoonful of powdered borax in half a pint of starch-solution. I urge upon you the adoption of this preventive measure for the following reasons: 1. It does not injure the fabric in any, imparts no disagreeable odor, and interferes in no way with the subsequent washing of the goods. 2. It does not prevent the formation of a smooth and polished surface in the process of ironing. 3. Borax can be found in every village, and is within the reach of all. 4. It is a cheap salt, and its use for this purpose very simple.

When I consider how inflammable are the dress-materials of women and young children, and that the loose and flowing drapery, by exposing so large an amount of surface to the air, is most dangerously promotive of rapid combustion; when I reflect that in the household service woman has so much to do with fire, and remember how many annually perish by this horrible form of death, I am in earnest in urging so simple and cheap a method of avoiding this needless waste of life. The following are samples of newspaper items of almost daily occurrence, showing how often women and children are horribly and fatally burned:

MASON—SHOCKING ACCIDENT—A WOMAN BURNED TO DEATH.

MASON, February 4, 1880.—A shocking accident occurred in Dansville last evening. Mrs. A. D. Beardsley lay down upon the bed with her little child and suddenly awoke to find her clothing in flames. Frantically seizing a bed-quilt she ran out of the house, screaming for assistance. Help soon arrived and the flames were smothered and the unfortunate woman again conveyed into the house, where, after a night of agony, she died this morning. She leaves a husband and four children. [*Post and Tribune.*]

LAPEER—CHILD BURNED TO DEATH.

LAPEER, February 11, 1880.—On Saturday afternoon of last week a three-year-old daughter of William Roberts, of Deerfield township, Lapeer County, was burned to death. She was playing with paper at the stove.

A daughter of Harvey Chaplin, of the town of Rich, aged ten years, was burned to death on Monday morning. The parents were absent from the house a short time, and on returning found the child with her clothes burned off. Coming in contact with the stove is the supposed cause. She lived only a few hours after the accident.—[*Post and Tribune.*]

FIRE-PROOF COMPOSITION.

Various combinations of ammonia and borax have been recommended in Paris for rendering fabrics incombustible, and I insert three of these:

1. Applicable to all kinds of goods:

Sulphate of ammonia	8 parts	Borax	1.7 parts
Carbonate of ammonia	$2\frac{1}{2}$ parts	Starch	7 parts
Boracic acid	3 parts	Water	100 parts

Steep the fabrics till thoroughly soaked, dry, and iron out.

2. For theatrical scenery, wood-work, etc.:

Boracic acid	5 parts	Gelatin	$1\frac{1}{2}$ parts
Chloride of ammonium	15 parts	Size	50 parts
Powdered feldspar	5 parts	Water	100 parts

Add enough whiting to give body, and apply (hot) with brush like paint.

3. For paper, securities, etc.:

Sulphate of ammonia	8 parts	Borax	1.7 parts
Boracic acid	3 parts	Water	100 parts

Heat the solution to 122° F., immerse paper in this, spread it out to dry, and press it to restore the glaze. It is nearly incombustible.

PROTECTION OF BUILDINGS.

Not only are textile fabrics liable to burn, but houses, barns, and outbuildings are exposed to the same danger. There are many ways of diminishing this danger, but no means of entirely removing it. Wood can be made comparatively uninflammable by saturating it with many salts, such as alum, copperas, etc. But if such wood is exposed to the weather, the rain will dissolve out these salts to a certain extent and the protection is diminished. Our buildings contain so much pine that they are very inflammable, and a spark may commence a serious conflagration. If we can make our buildings secure against these apparently trifling causes of fire, we have done much to promote security from fire. The overturning of a kerosene lamp was the origin of the great Chicago fire; a fire-cracker laid the city of Portland in ashes, and similar trivial causes may produce like effects if the present combustibility of our buildings remains unchanged. Even if we cannot prevent fires, if we can retard the rapid spread of the flames, we greatly increase the chances of extinguishing the fire.

Wood can be made quite uninflammable by coating it with soluble glass or silicate of soda. This pine shingle which has been coated with solution of the soluble glass, I hold in this hot flame, but the wood does not burn with a blaze, but only chars. The cheapest way of rendering outbuildings, fences, etc., incombustible, is by *yellow-washing* them with common water-lime and skim-milk, prepared in the same way that white-wash is made, except that water-lime and skim-milk are used instead of lime and water; the addition of a half a pound of common salt to each gallon of yellow-wash will improve its quality and increase its power of resisting fire. Lime and casein, or curdy matter of milk, will combine after a time and form a very hard and indestructible mass. The coating formed by water-lime and milk has some of the properties of oil-paint in excluding water, but has a power which paint wants of resisting fire. It forms a hard and closely-adhered covering to wood, not liable to rub off like white-wash, and has a very agreeable stone-color instead of the ghastly white of white-wash. The wood covered with this yellow-wash can hardly be made to blaze. Here are shavings and shingles which have been coated with this yellow-wash, but I cannot make them blaze.

If our cheap outbuildings, fences, etc., were covered with this yellow-wash where we cannot afford paint, their appearance would be much improved, and many serious conflagrations might be prevented.

SPONTANEOUS COMBUSTION.

Buildings sometimes take fire by spontaneous combustion; a substance undergoing active oxidation may produce enough heat to take fire. This is especially true if the substance is porous, so as to expose a large surface, and it is a good non-conductor of heat; hay and grain when recently stored in the barn after harvest; dung-heaps, etc.; greasy rags, or clothes smeared with varnish, are very liable to spontaneous combustion.

ASHES.

Many buildings are fired by careless disposal of ashes. Ashes conduct heat very slowly, and hence they will keep coals alive for a long time. The too common practice of placing them in boxes or barrels, even after they seem to be cold, is unsafe. Ashes sometimes take fire again and become a bed of hot cinders, even weeks after they have been removed from the fire. The cause of this is not well understood, but may possibly be from oxidation of potassium by moisture. It is never safe to place ashes in or near any combustible material.

My closing advice is this: Use fire as your servant and make him keep his proper place; let him never become your master either in the present or in the hereafter.

Agricultural College, Lansing, Mich., February 6, 1880.